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Laser Stabilization for Near Zero NO_x Gas Turbine Combustion System

at

Turbine Power Systems Conference and Conditioning Monitoring Workshop

February 25-27, 2002

Contract: DE-FC26-01NT41230

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Outline

- Program Overview
- Technical Issues
- Plans
- Status

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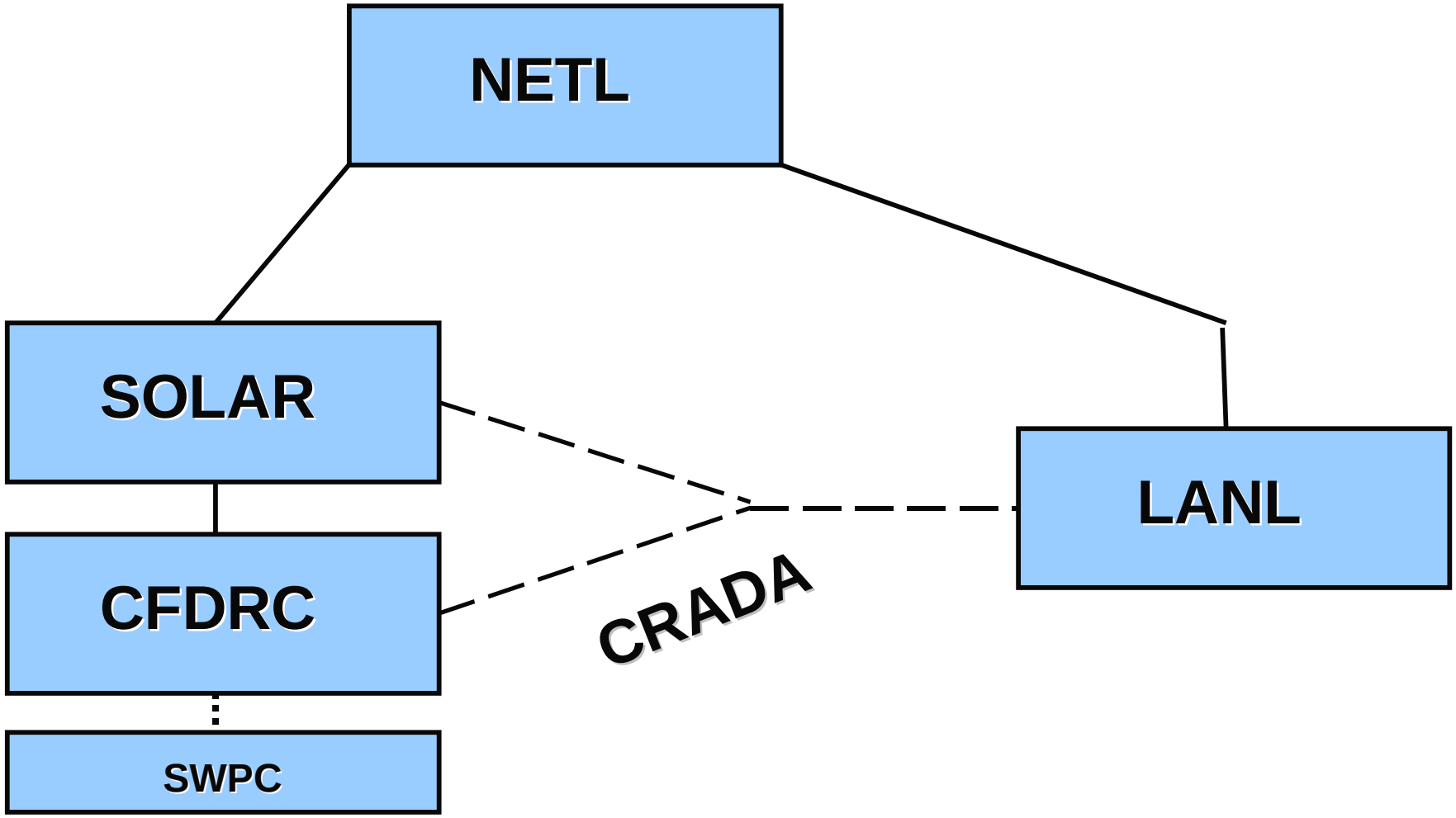
Program Structure



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Program Details

- 4 Year Duration (10/01 start)
- Solar / CFDRC cost share
- DOE Project Manager: Norm Holcombe

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Technical Goals

- **Demonstrate A Pulsed Laser System For Gas Turbines:**
  - **Reduce Combustor Oscillations**
  - **Enhance Lean Stability to Allow Near-Zero NOx Emissions**
- **Develop & Validate LES/CFD Models For Transient Combustion**

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Applications

- **Can or Can-Annular Combustion Systems**
- **Multi-Injector Annular Combustors**

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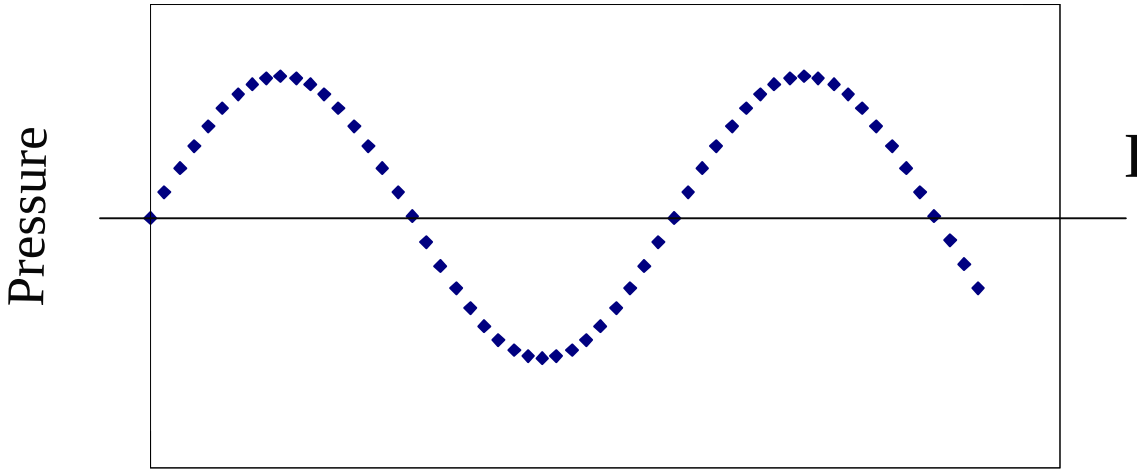
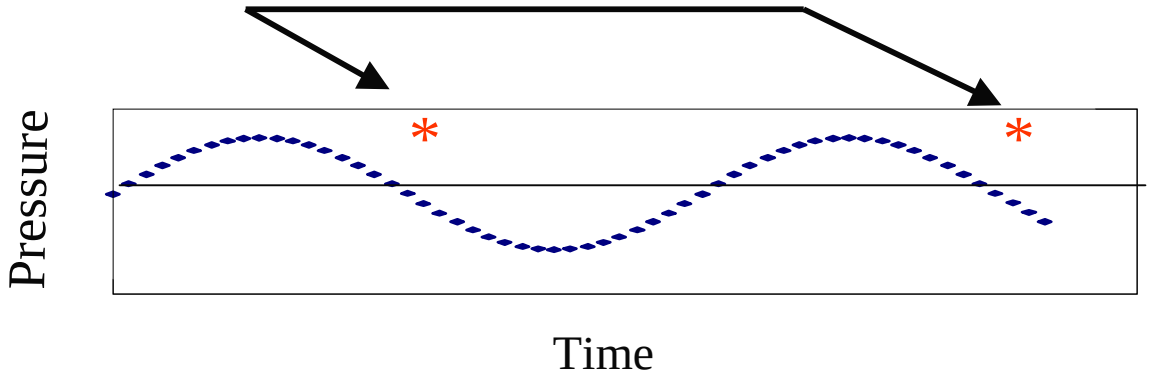
Annular Combustors

Technical Approach

CONTROL STRATEGY

Alter Local Heat Release Within The Flame Through Laser-Assisted Ignition





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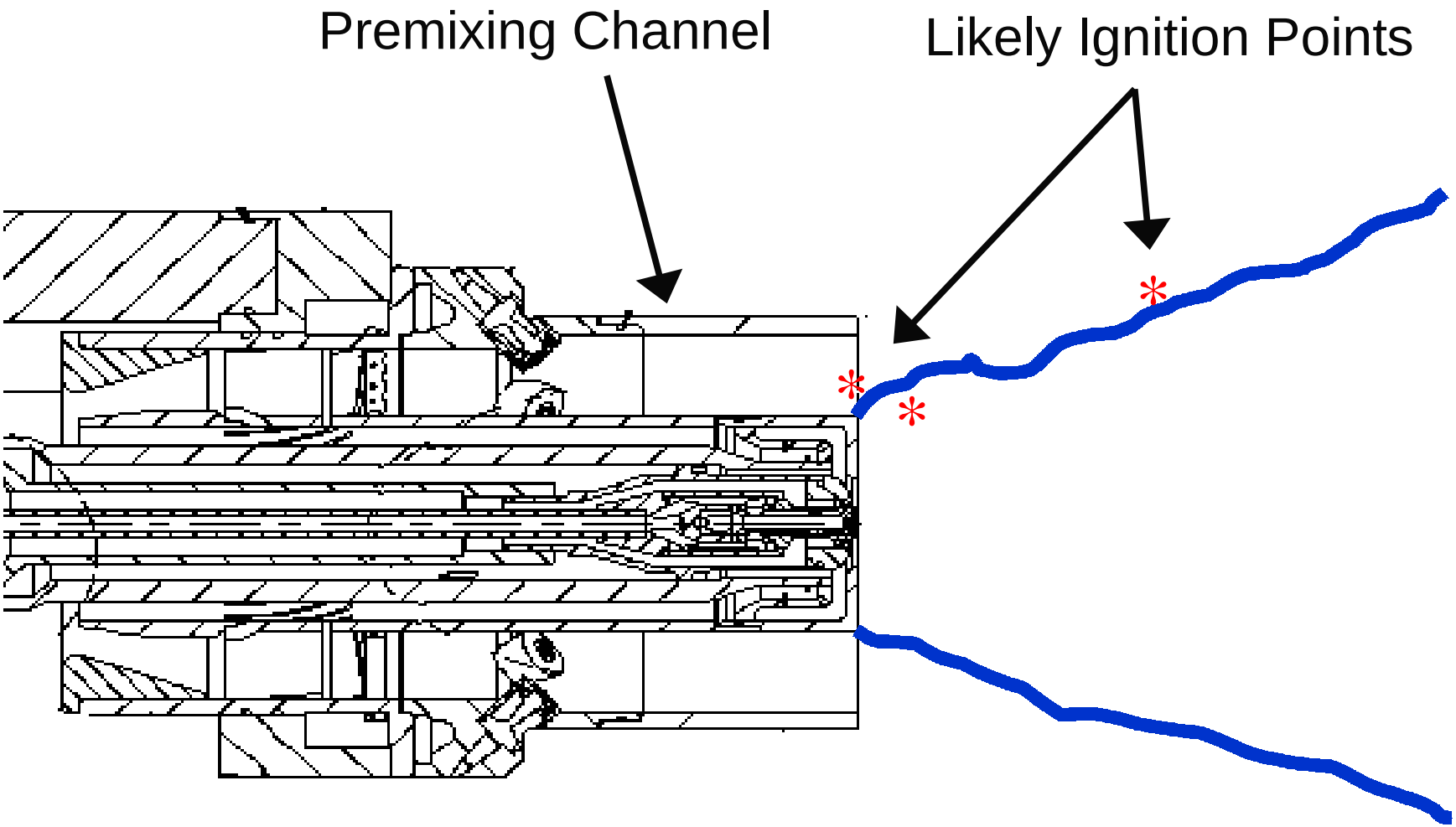
Fuel Injector Cross-Section



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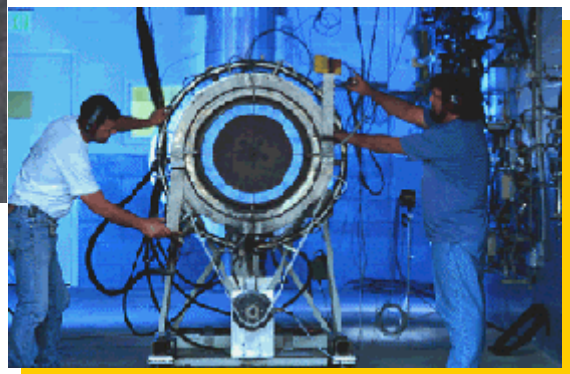
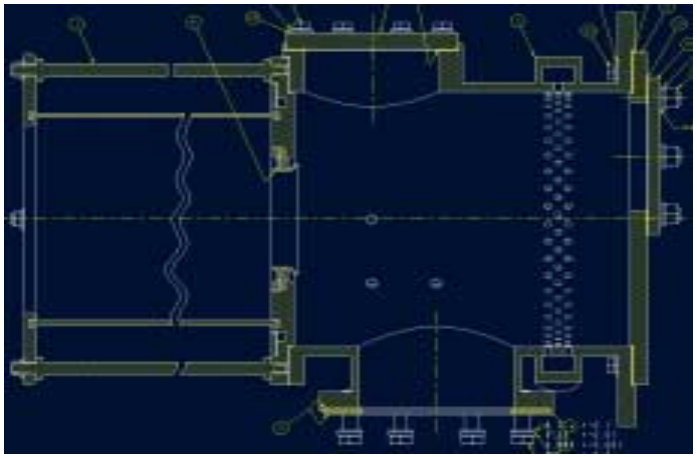
Test Facilities

Single Injector Rig



Full Combustor Rig

Engine Ri



Single Injector Atmospheric Rig

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Single Injector Rig Tests

- **Atmospheric Pressure Combustor**
  - Quartz for better visibility
  - Low pressure for ease of access
  - Provides an early assessment of concept feasibility
- **High Pressure Can Combustor**
  - Testing at realistic engine conditions

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Technical Issues

- **Laser System**
  - Power requirements
  - Pulse duration
  - Pulse frequency
  - Multiplexing
    - Couple multiple lasers to obtain higher frequencies
    - Provide laser pulses to multiple injectors

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Technical Issues

- **Active Control System**
  - Control system hardware and software definition
  - Sub-harmonic control of combustion oscillations
  - Effective control frequency window
  - Amplitude
  - Phase

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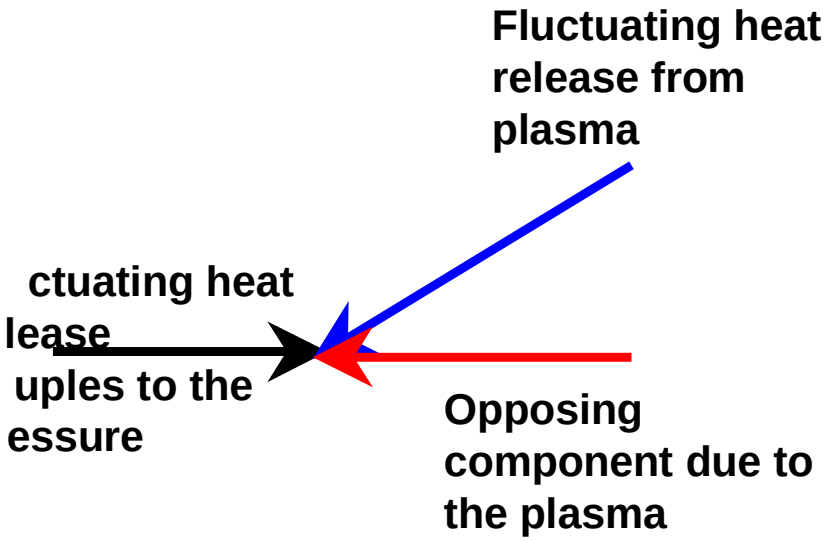
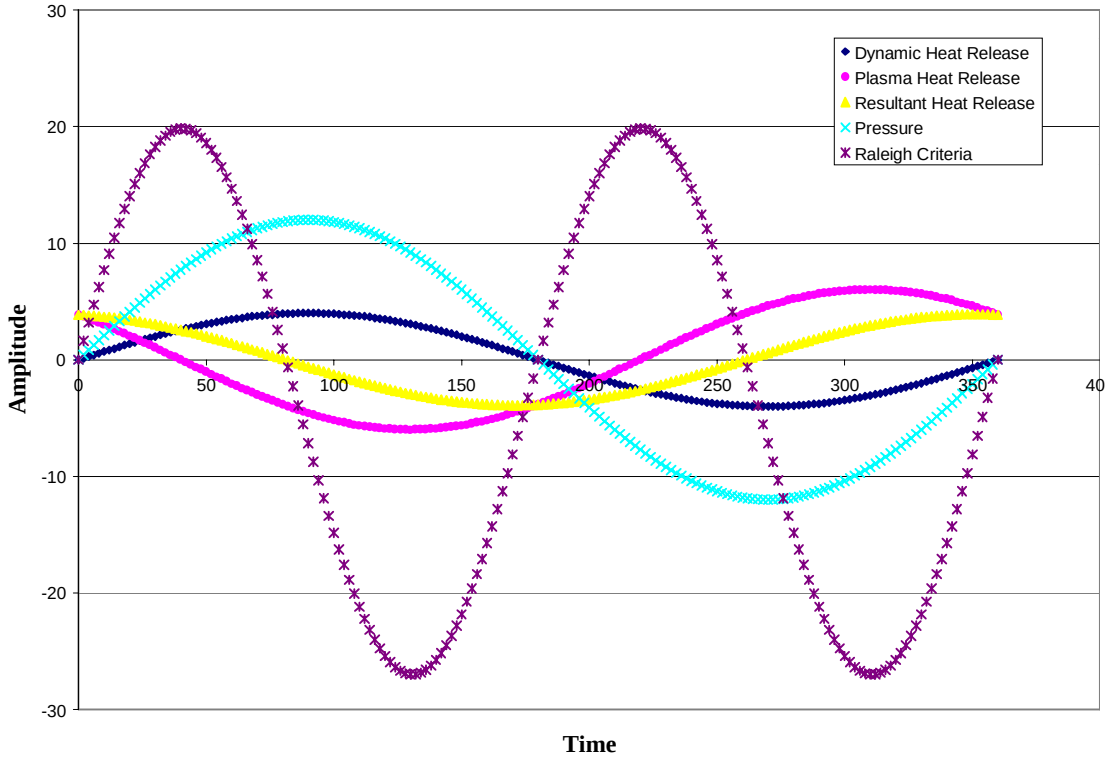
Vector Representation of Control Process

- Laser pulse (magnitude, phase and duration) relative to pressure oscillation determines the amount of control





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Technical Issues

- **Implementation on Gas Turbines**
  - Optical access in commercial turbines
  - Durability
  - Cost
  - Packaged control system

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Program Plan

Year	Activities

1	• Single Injector Rig Tests
	  • Proof-Of-Concept
	  • Parametric Tests
	• CFD Modeling

2	• Laser System Definition • High Pressure Rig Tests • Optimization • CFD Modeling

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Program Plan

Year	Activities
3	• Multi-Injector Combustor Rig Tests • CFD Modeling
4	• Engine Demonstration • Centaur GT

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Status

- **Setting up for atmospheric pressure test**
  - Baseline data (LBO and oscillations)
  - Impact of laser pulsing
- **CFD calculations underway to assess plasma effects on combustion**